

August, 2020

Can we see smells?

Technology of smell visualization is under development!

Smell analysis technology accelerated by AI

Smell Sensor vol. 1

Do you know how a human being senses smell? Research on olfaction has been delayed compared to the other areas of senses. We interviewed Masashi Hattori, who is in charge of smell sensor R&D projects, about the mystery and the future of 'smell' sensor development.

Our navigator

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Masashi Hattori (Section Chief)



Deceiving the eye?

The mysterious world of smells

"Human sense of smell is not as perfect as we think."

Mr. Hattoi, who is in charge of developing smell sensors, began to explain. What are smells in the first place? According to Mr. Hattoi, the development of smell sensors started from understanding what smells are. At the beginning, he described a sample experiment.



▲Mr. Hattori explains the mechanism of smell.

Having majored in engineering, smells, which is a biological subject, was for him an unknown field.

Hattori: If test subjects smelled an apple while looking at a picture of an apple, almost all of them answered that it is the smell of an apple. But if they only smelled an apple without confirming visually, the percentage of correct answers dropped to approximately 50%. The human sense of smell is complemented by the sense of vision and other information sources.

For animals to sense smells, olfactory receptors, which are structures for sensing smell, play an important role. It is like a sensor in engineering. The existence of olfactory receptors was confirmed as late as in the 1990s, which were determined to be the mechanism for sensing smell.

— What mechanism is it?

Hattori: The relationship between a smell molecule and an olfactory receptor is like a key and a keyhole. When a smell molecule (key) fits into the olfactory receptor (keyhole), the smell is sensed.

Hattori: The olfactory cells are like converters in engineering. They change the smell captured by olfactory receptors into electrical signals, which are sent to the brain, where they are matched against past memories and identified.

— The more olfactory receptor types we have, the more types of smells can we identify?

Hattori: That's right. A human has about 400 types of olfactory receptors. However, a dog has 800, more or less, which is why a dog's sense of smell is believed to be 1,000 to 100 million times superior to that of a human. Nematodes, or roundworms, have 1,200 types of olfactory receptors, which is more than a dog. They react to the smell of urine collected from cancer patients at the early stages of disease with a probability of 90%. A cancer diagnosis kit using their olfactory senses can perform a cancer diagnosis with a single drop of urine.

Potential Value of the Growth-Promising Smell Sensor Market

Still an untapped field, the smell market is expected to have a promising future. We asked Mr. Hattori about the smell sensor, which is hoped to have a variety of applications.

— What made TAIYO YUDEN enter the field of smell sensors?

Hattori: Among the five senses that humans possess, only the sense of smell had not been commercialized, and we found that the potential value of the smell sensor market is very high. In addition, our material technologies for organic and inorganic materials as well as piezoelectric materials play an essential part in developing this product.

Hattori: The reason why we did not enter the smell sensor market, where there were no competitors, was that we did not know much about smells. (Wry smile)



▲QCM-type prototype smell sensor under development

Digitizing smells with our proprietary technologies and AI technology

The sense of vision is composed of three primary colors (red, blue and yellow). The sense of taste is composed of five flavors (sweet, sour, salty, bitter, and Umami). However, for smells, there are several hundred thousand in nature, and there are no basic smells. The difficulty lies in which dimensions smells can be analyzed and assessed.

Hattori: Each smell we usually recognize consists of several types of olfactory molecules. For example, the smell of coffee is made up of about 100 types of smells, which can be instantaneously recognized by the human brain. Realizing this process with a machine was a difficult task. However, thanks to recent advances in AI, it is now possible to conduct complicated calculations and analyses simultaneously. How to exploit AI will be the key to commercialization.

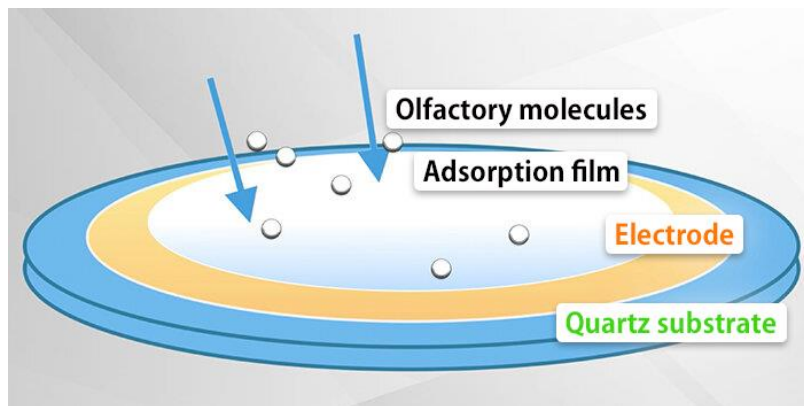


▲A box with a PC connector and suction/exhaust port

The internal pump suctions and exhausts air to refresh the smell ingredients inside.

What is the mechanism of a smell sensor with AI pattern learning and analysis?

The smell sensor developed by TAIYO YUDEN has 16 channels, which correspond to the olfactory receptors of a human*, and digitizes the detected smell. By teaching the AI various patterns of smells in advance, when an actual smell is detected, the nearest pattern is found and the smell is identified.



▲ Principle of Analyzing Smells

When olfactory molecules come into contact with the adsorption film on the quartz substrate, the resonance frequency of the quartz changes, which is analyzed to identify the smell.

— The higher the sensitivity of each channel, and the more the number of channels, the nearer to the human sense of smell we get, right?

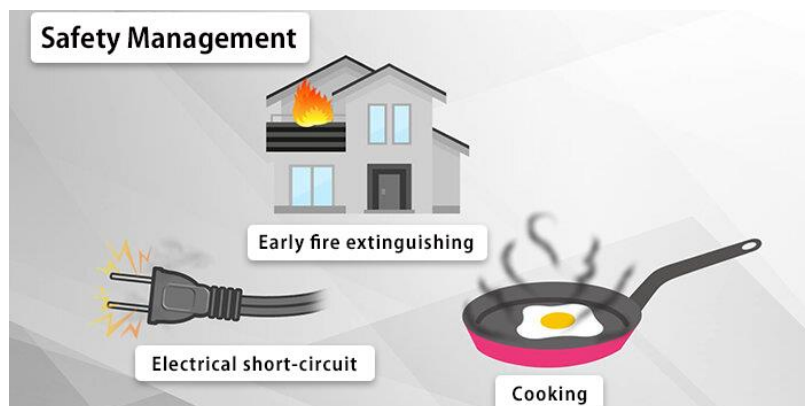
Hattori: That's right in theory. For the number channels, which now stands at 16, by increasing it, it will be possible to detect more types of smells. However, it is not easy to implement 400 channels, like a human, in an industrial product. Actually, we may not need that many channels. Only the types of smells that need to be detected should be provided.

What we should do is to raise the sensitivity, rather than expanding the range of smells (by increasing the number of channels). For some smells, we have a sensitivity similar to the human nose. If we can enhance this to the level of a dog, the application of this technology will expand.

— In which fields do you think commercial smell sensors will be used?

Hattori: Many customers are requesting applications for abnormality detection and preventive maintenance. In the near future, declining birthrates will make it difficult to acquire workforces for safety inspections. I suppose many companies are thinking of utilizing sensors for this task.

In fields of work that are currently carried out by human labor, no workforce will be available in several years, so finding alternative is an important issue.



▲ Smell Sensor Applications

Abnormality detecting solutions by sensing smell molecules from smoke and other gasses

— Looking at other fields, in agriculture for example, is it possible to determine the best harvest timing for fruits by sensing smells?

Hattori: There are such requests. Fruits generate special gases, and we can determine maturity using smell. If fruits are overripe, rotten-like odor gases are produced. Determining when they are ready to eat using a smell sensor will become possible in the near future.

We are currently working toward enhancing the level of sensing smells from that of a human to that of a dog. If we exceed the levels that animals possess, our sensor will find unexpected applications, which we hope will contribute to human advancement.



▲ Evolving the smell detection technology that makes it possible to replace functions fulfilled by animals and humans, and enhancing them (Schematic)

Hattori: If a smell sensor at the dog sensitivity level is commercialized, it will replace drug-sniffing dogs and bomb detection dogs, which is good from the viewpoint of animal welfare. In addition, it takes 7 to 8 years to raise such dogs, and these laborious tasks restrict working hours, which result in enormous costs. If smell sensors replace these functions, their market value will be high.

Fields under consideration for smell sensor applications. How will this change our life?

Mr. Hattori said that smell sensors and smell analysis technologies will also be applicable to healthcare, security, and disaster prevention.

For example, when a human is under stress, tiny amounts of gases are released from the skin. Detecting such gases with a wearable terminal will enable daily health monitoring. It is said that a dog identifies persons by their smell. Therefore, personal authentication by smell could also be possible. Moreover, detecting changes in gases in the soil could make it possible to forecast landslides.

Through the interview, we saw unlimited potential for smell sensor technology.

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